A DESCRIPTION AND PALEOECOLOGIC STUDY OF CONODONTS FROM THE PINERY LIMESTONE MEMBER OF THE BELL CANYON FORMATION (UPPER PERMIAN), GUADALUPE MOUNTAINS, WEST TEXAS

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ABSTRACT

Thirty-nine samples (three of which were unproductive) from three different sections of the Pinery Limestone member of the Bell Canyon Formation (Upper Guadalupian in age) from the Guadalupe Mountains National Park and D-Ranch lands yielded more than 2,900 conodont elements, which are assigned to nine species and one subspecies of five genera. Six new species and one new subspecies are established from this material. Distribution of these species indicates that there were three different contemporaneous conodont faunal assemblages whose distribution was probably controlled by water depth and differences in salinity.

INTRODUCTION

Much of the previous work on Permian conodonts in North America has been done on western North American sections other than the standard North American Permian section of West Texas. This has been due to the belief that few conodonts can be found in the type section in West Texas.

In 1969, when Clark and Behnken were in the process of summarizing information on Permian conodonts for the Symposium on Conodont Biostratigraphy, S. P. Ellison sent them a communique in which he stated that extensive studies of various facies of the West Texas Permian section yielded only fragmented material. Clark has also stated that few of his samples from Texas have produced conodonts. Thus, the bulk of the biostratigraphic work on Permian conodonts has been done on other western American sections. Studies have been made in Wyoming, Utah, and Idaho (Phosphoria Fm. and equivalent Park City Fm.), and in Nevada (Gerster and Plympton Fms. and underlying Kaibab Limestone; and Reipe Springs and Riepetown Fms.). Correlation of these sections with the Texas standard section is at best only sketchy.

Clark and Ethington (1962) described an abundant and well-preserved fauna from what they considered to be the Bone Springs Fm. (Leonardian in age). Recent work by Furnish and Glenister has shown that this collection was made from the Brushy Canyon formation (Lower Guadalupian).

The presence of well-preserved conodont elements in rocks of Guadalupian age was first brought to the author's attention by Dr. Walter C. Sweet, who had received small samples of Guadalupian age rock in 1971 from West Texas. Some of these produced a quantity of well-preserved conodont elements. In the summer of 1972, the author collected bulk samples from three sections of the Pinery Limestone member of the Bell Canyon formation (Upper Guadalupian), which contains five limestone members. These exist as tongues that built out into the Delaware Basin from the Capitan reef in the area of the Guadalupe Mountains National Park. The samples obtained from these sections produced numerous, well-preserved conodont elements. Other work on the Permian of West Texas is currently being done by some of D. L. Clark's students, at the University of Wisconsin.

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STRATIGRAPHY

The standard North American Permian section of West Texas has been divided in ascending order into the Wolfcampian, Leonardian, Guadalupian, and Ochoan Series. The Guadalupian Series (King, 1948, Delaware Mountain Group) has been further subdivided into the Brushy Canyon, Cherry Canyon, and Bell Canyon formations, the latter of which includes the Hegler, Pinery, Rader, McCombs (Flaggy), and Lamar Members. The material for this report was collected from the Pinery Limestone Member of the Bell Canyon Formation.

The first section sampled (Fig. 1) is King's section 63 in Pine Springs Canyon (King, 1948) and consists of 151 feet of bedded limestone. The Pinery Limestone Member in this section is underlain by sandstone. The basal Pinery consists of 23 feet of less resistant, dark gray, cherty limestone. This is overlain by 21 feet of massive light gray limestone, above which is 86 feet of less resistant thin-bedded dark gray cherty limestone with lenses of fossil fragments. The upper 43 feet is a gray to light gray massive, coarse grained limestone with lenses of fossil fragments.

A second section (Fig. 1) measured and sampled along Rader Ridge, west of Nickel Creek Gas Station consists of 86 feet of dark gray, thin-bedded, cherty limestone. The basal 40 feet is a more or less massive limestone which grades upward into a less massive thin-bedded limestone interbedded with thin beds of sandstone. The upper 15 feet consists of thin-bedded limestone interbedded with sandstone.

The third section was measured and sampled at the intersection of Bell Canyon, Lamar Canyon, and to road to D-Ranch, on the northeast canyon wall, just north of the cattle-shipping pens (Fig. 1). This section consists of 27 feet of thin-bedded, dark gray, silty, hard limestone interbedded with thin beds of sandstone.

In addition to the material collected for this report, the author also collected material from the South Wells and Manzanita members of the Cherry Canyon Fm. as well as from the Hegler, Rader, and

Lamar members of the Bell Canyon Formation for study by Dr. Walter C. Sweet.

PINERY CONODONTS

Thirty-six of the 39 samples collected for this report were productive and yielded 2,962 conodont elements. Additional material was studied from sample 71SA-12 (Cibolo Fm.) loaned to the author by Dr. Walter Sweet. These elements represent nine species and one subspecies of five genera.

Six new species (Neogondolella sp. c Croft; Anchignathodus sp. a Croft; Anchignathodus sp. b Croft?; Ellisonia tribulosus (Clark and Ethington) 1962, aff. E. gradata Sweet; Ellisonia sp. t Croft aff. E. teicherti Sweet; Ellisonia festiva (Bender and Stoppel) 1965, aff. E. triassica Muller) are described. In addition, one new subspecies, Neogondolella sp. c subsp. sc Croft is described.

Conodonts in the author's collections are unaltered and very well preserved (some samples are in an excellent state of preservation). Specimens range in color from amber to dark amber. The gondolelliform elements dominate in the samples and many are unbroken. Some of the samples (e.g., 72PLM-18a, 72PLM-31) contain quite youthful growth stages of these neogondelliform elements. The ramiform elements are also, for the most part, quite well preserved. Several samples (e.g., 72PLM-18a, 12PLM-19) contain nearly perfect specimens. Specimens were collected from bulk samples averaging 1,100 g. (range from 600-1,500 g.) and the numbers collected were normalized for sample weight to conodonts / 1,000 g. (figures listed in Tables 1-3).

ECOLOGIC SIGNIFICANCE OF THE CONODONTS

A severe conodont faunal crisis occurred during early Wolfcampian times (Clark, 1972). Conodonts were on the very threshold of extinction, and only three main stocks survived into the Late Wolfcampian (Neogondolella, Anchignathodus and Ellisonia-Xaniognathus). These were the ancestral stocks for all the Permian and Triassic conodonts that followed.

With this in mind the author turned to the Delaware Basin to study faunal relations because the basin offers the unique opportunity to collect material from an area that has suffered little deformation since the rocks were deposited (King, 1942, 1948) and in which the approximate water depth at the time of deposition can be deduced. The author chose the Pinery Limestone member because it offered a thin, discrete, stratigraphic unit that could be sampled at the edge of the Capitan reef and on out into the basin.

By analogy with modern reefs, it is assumed that the reef grew at or very near the surface of the sea, and that back-reef sediments (Carlsbad Limestone) were deposited in very shallow water only a few tens of feet deep (Kendall, 1969). This provides a datum point from which relative water depth can be measured. The author's material was collected 6.7 miles east, 2 miles east, and just below the reef margin. During the time in which the Pinery Limestone Member was deposited the water depth two miles from the reef margin was approximately 1,500 feet. Six miles from the reef margin the water was over 2,700 feet deep. These measurements can be taken from the topographic map of the area (also see Newell and others, 1953).

During periods of limestone deposition in the basin the reef was growing vertically and water depth was increasing in the basin. During periods of deposition of sands in the basin the reef was growing laterally, over more or less stable conditions, and terrigenous sands filled and overflowed the lagoon, as prograding deltas crossed the reef, and spilled into the basin.

The deeper waters were stagnant, as is evidenced by the lack of Benthonic fossils and the characteristics of the rocks (e.g., marcasite is a component of the fine fraction in several D-Ranch samples). Sponges with siliceous spicules inhabited the basin slopes and siliceous spicules are prominent in all the Rader Ridge samples. Most pelagic animals probably inhabited the upper depths (less than 300 feet) much as they do in recent oceans (Odum, 1972). Thus, the Pine Springs Canyon section, close to the reef margin, would be the only section in which one would expect to find any evidence of vertical stratification of conodont faunals.

In an attempt to investigate faunal relations the author has plotted the total number of conodonts per sample. This has been compared with the percentages of each of the two Neogondolella species versus the Ellisonia, Xanignathus, Anchignathodus, and Prioniodella species taken together (these species trend together on a graph when plotted individually and the author interprets them as having been components of a single faunal assemblage).

In the Pine Springs Canyon section (Fig. 4) changes in water depth during deposition might be represented by fluctuations in the relative abundance of deeper water and shallower water conodonts in successive samples. Samples with relatively large numbers of specimens can be assumed to reflect more stable conditions and water depth might have been shallower during deposition of such samples relative to those found in periods of subsidence and more rapid deposition. Relative abundance of the Ellisonia fauna increases in samples in which conodont-element numbers increase. This suggests that the Ellisonia-type fauna might have occupied a shallower water depth relative to the Neogondolellas. Thus when conditions were stable, and water depth relatively shallower, the relative abundance of the shallower-water fauna might increase. When there was less water for the deeper-water fauna to occupy, it contributed a smaller percentage of individuals to the sediments and the relative abundance of the shallower-water fauna increased. In short, this might suggest that the Ellisonia-type fauna occupied a shallower water depth relative to the Neogondolella fauna.

As the Rader Ridge section (Fig. 5) is examined one finds that the general trend is toward an upward increase in the percentage of Ellisonia-type elements. Since water depth was probably not a factor in this case, this increase suggests a horizontal as well as a vertical array of faunal habitats. When the Pine Springs Canyon graphs are compared with the Rader Ridge graphs, one finds that relative abundance of the Ellisonia-type elements increases at Rader Ridge in the intervals it decreases at Pine Springs, and increases at Pine Springs in the intervals it decreases at Rader Ridge. This suggests a lateral migration of the Ellisonia-type fauns. These assumptions are true if one assumes that the bases of the Pinery sections coincide.

During periods of vertical reef growth the water depth in the basin was increasing (Newell and others, 1953). Since subsidence did not affect the shallow shelf areas (Newell and others, 1953), it is assumed that the water depth must have slightly decreased during periods of subsidence in the basin. As the water depth decreased the salinity increased. As the salinity increased, carbonate deposition increased just behind the reef margins where more normal waters mixed with more saline waters (Kendall personal communication).

This might tend to increase the salinity further as the water depth decreased. If one examines the stratigraphic section at Pine Springs Canyon, it is found that percentages of the Ellisonia-type elements drop to zero soon after passing into the coarse-grained massive light-gray limestone beds. Percentages increase during the same interval at Rader Ridge. This might suggest a lateral migration by the Ellisonia-type fauna during periods of higher salinity at the reef margin.

If the D-Ranch section is examined (Fig. 6), one finds that distributions of Neogondolella c Croft, and the Ellisonia-type faunas are generally parallel, and these figures parallel the relative rates of sedimentation as indicated by total number of conodonts per sample. A new faunal element (Neogondolella c sc Croft) is also represented. Since water depth was probably not a factor in upward changes in relative abundance in the D-Ranch section, these changes must also reflect a horizontal migration of faunal assemblages. Migration of Ellisonia-type elements, as inferred in the Rader Ridge section, probably did not extend this far out into the basin. Since the percentages parallel each other, the percentages of Ellisonia-type elements are relatively higher in the D-Ranch section than in the other two sections. In addition, as was previously mentioned, a new species appears here. Since N. c sc Croft is closely related to N. c Croft, morphologically and in relative abundance, it is suggested that N. c sc Croft might be even deeper water Neogondolellas or are restricted to more open waters of more normal salinity.

In summary, there appear to have been interrelated differences in vertical and lateral distribution of conodonts during deposition of the Pinery Limestone Member. The Ellisonia-type association seems to have inhabited shallower water, and the Neogondolella species relatively deeper water. In addition, the Ellisonia-type association appears to have migrated away from the reef margin during times of subsidence in the basin and subsequent filling of the back-reef lagoons. The author suggests that migration away from the reef margin might have been a result of increased salinity in the back-reef lagoons and at the reef margin. However, one must bear in mind that these conclusions are strictly hypothetical. If the bases of the Pinery Limestone Member are not coincident, evidence of a lateral migration of the Ellisonia-type fauna is weakened. If the base of the Rader Ridge section is shifted up ten feet relative to the base of the Pine Springs Canyon section, the increases in relative abundance of the Ellisonia-type fauna roughly match.

SYSTEMATIC PALEONTOLOGY

The skeletal apparatuses of four of the species and the one subspecies described on the following pages are believed to have included only dextral and sinistral elements of a single morphologic type. The author is uncertain of the affinities of two of the species. No statistical evaluations were attempted. The remaining three species appear to have had multi-element skeletal apparatuses. These conclusions were based on statistical evaluations (Sweet, 1970) of species that are closely related to the ones described on the following pages. All specimens will be housed in the Orton Museum of The Ohio State University.

Genus Anchignathodus Sweet, 1970

Type-species, Anchignathodus typicalis Sweet, 1970.

Anchignathodus, as proposed by Sweet (1970) ranges from Lower Carboniferous to Lower Triassic. Skeletons of species referable to the genus consist of dextral and sinstral bladelike elements, with a distinct posterior process that extends over a broad, expanded, cup-like basal cavity. The laterally compressed denticles descend posteriorly from a cusp that is larger than any of the denticles. Elements of some species (e.g., A. isarcicus) have denticles developed anteriorly to the cusp or laterally on the flanges of the basal cavity.

Anchignathodus sp. a Croft

Pl. 1, Fig. 1-3; Text Fig. 7, B-C

? Gnathodus sicilianus Bender and Stoppel, 1965,

Pl. 14, Figs. 2a, b (juvenile specimens), not Pl. 14, Fig. 1, 3

? Spathognathodus sp. Clark and Ethington, 1962,

Pl. 1, Fig. 6

Diagnosis: A species of Anchignathodus characterized by arched, blade-like skeletal elements with a length to width ratio of 5:3. 1.6 to 1 Denticles are laterally compressed and decrease in length from the cusp forming a descending arch (see Text Fig. 7, tables). The denticles are small and fused for most of their length; the average number is 11; and they surmount a broadly flaring basal cavity that terminates in a basal pit beneath the cusp. The cusp tends to be approaching the prominent delta-shape found in later forms. White matter tends to be a rather evenly distributed haze; however, the posterior edge of the cusp is more translucent than the anterior part.

Remarks: The author's material consists of 15 discrete elements from matrix of an ammonoid identified as Waagenoceras guadalupense Girty from the Cibolo Formation (Guadalupian), Chinati Mountains and the Lower Pinery Limestone of West Texas (72PLM-14-15; 71SA-12). A. sp. a Croft appears to be part of an evolutionary sequence beginning with Pennsylvanian forms (A. minutus Ellison) and continuing through A. julfensis Sweet and A. typicalis Sweet (Text Fig. 7). The trend seems to be toward the development of a distinctive large delta-like cusp, and a general elongation of the element with an increase in the size and decrease in number of the denticles. White matter in these later forms tends to be concentrated in the denticles and along the posterior margin of the cusp.

Anchignathodus sp. b Croft

Pl. 1, Figs. 3-10; Text Fig. 7-D

Diagnosis: A species of Anchignathodus characterized by arched and bowed blade-like elements with a length to width ratio of 2:1. Denticles are laterally compressed and decrease in length as they descend from the anterior cusp to form a bow with a posterior hump (see Text Fig. 7-D). The denticles are rather large; rounded (particularly in mature specimens); fused for most of their length; and average eight in number. The cusp has a prominent delta-like shape and becomes slightly bifid in mature specimens, as in elements of A. julfensis Sweet. The cusp occupies the anterior third of the element. White matter is concentrated in the posterior edge of the cusp and in the denticles. The anterior portion of the cusp is thin and translucent, as is the rest of the element. A basal pit terminates under the cusp from the typical Anchignathodus basal cavity.

Remarks: The author's material contains 76 specimens. Elements of Anchignathodus sp. c Croft differ from those of A. julfensis Sweet and A. typicalis Sweet in that A. julfensis elements have a distinct fused posterior hump in all growth stages and denticles of A. typicalis elements descend regularly from the cusp and the posterior hump is lacking.

Occurrence: Pinery Limestone Member of the Bell Canyon Formation, West Texas.

Genus Ellisonia Muller 1956

Type species, Ellisonia triassica Muller 1956.

In 1970, Sweet indirectly expanded the concept of the genus Ellisonia, which originally included only hibbardelliform elements, by adding seven multi-element species (E. clarki, E. delicatula, E. gradata, E. robusta, E. teicherti, E. torta, E. triassica). All these species are uppermost Permian and Lower Triassic in age. Other multi-element conodont species with some of the same form elements range from the Ordovician through the Triassic. Sweet did not try to examine all these species and assign them to genera. He used the name Ellisonia because its type species (E. triassica Muller) is a hibbardelliform element of the multi-element species E. triassica, which Sweet recognized in his material from West Pakistan (Sweet, 1970).

The author also uses the name Ellisonia, because parts of his material are closely related to three of the Lower Triassic species assigned to that genus and are of similar age (Upper Permian). The author also recognizes that Sweet has indicated in his paper on the Julfa Region of Iran (Sweet unpublished) that the genus Ellisonia might be further subdivided into three subgroups. In one group (E. triassica) the apparatus lacks an LC element, while in the second group (E. teicherti) the apparatus not only lacks an LC element but the U-element lacks a denticulated posterior process. The third group (E. clarki,

E. delicatula, E. gradata, and E. torta) has both an LC-element and a denticulated posterior process on the U-element. As previously stated, the author chooses to use the name Ellisonia for apparatuses of all three types.

Ellisonia sp. __t__ Croft,

Pl. 2, Fig. 9-12

? Hindeodella sp. a Bender and Stoppel, 1965,

p. 344-345, pl. 15, Fig. 6

Diagnosis: A species of Ellisonia that is closely related to E. teicherti Sweet, and with an apparatus that consists of LA, LB, and presumably U, LD, and LE elements, although the latter elements do not occur with the few specimens obtained by the author. White matter occurs only in the needle-like denticles.

The LA-element has two lateral processes. One process is broken near the cusp in the author's material. The other process curves slightly posteriorly and the cusp is twisted to face this process. The cusp and denticles are laterally compressed. Both are opaque with white matter and their proximal parts appear to be submerged in a translucent amber base.

The under surface of the element bears minute basal grooves that terminate in a basal cavity beneath the cusp.

The LB-elements are similar to the LA-elements, with an erect inclined cusp. The short anterior process is laterally deflected and bears a denticle almost as large as the cusp in most specimens; however, this denticle appears to be lacking in at least one specimen (Pl. 2, Fig. 10).

Remarks: This species is very similar to E. teicherti Sweet. However, teicherti elements have uniformly distributed white matter at all growth stages. Hindeodella sp. a Bender and Stoppel may in fact be an element of E. sp. t Croft since it is of similar age. The author is unable to determine this as the element has been coated. The author's collections contain 12 specimens.

Occurrence: Pinery Limestone, West Texas, ? Rupe del Passo di Burgio, Middle Permian, Sicily.

Ellisonia festiva (Bender and Stoppel), 1965,
Pl. 1-2, Figs. 14, 15, 16; 5, 6, 7, 8

Lonchodina festiva, Bender and Stoppel, 1965,
Pl. 15, Figs. 9, 10

Lonchodina festiva, Bender and Stoppel, Clark
and Behnken, 1970, Geol. Soc. America,
Menoir 127, Pl. 2, Fig. 9

Diagnosis: A species of Ellisonia with a skeletal apparatus composed of U-elements with a denticulated posterior process, LA-elements and LB-elements. Although no LF-elements have been found, E. triassica Muller, which is closely related, has LF-elements in its skeletal apparatus.

The elements are golden in younger specimens, and dark amber in mature specimens.

The U-elements have a long denticulated posterior process and a cusp with an oval cross section. The cusp is flanked by two short denticulated lateral processes with one to two denticles each. The base of the element bears a basal groove and wedge-shaped lateral attachment surfaces. No basal pit is evident.

LA-elements have a sturdy rounded cusp, several stout denticles, and a prominent basal cavity with a flared brim.

LB-elements are only fragmentary in the author's material, but they closely resemble the LB-elements of E. triassica Muller in shape and size.

Remarks: The author's material contains two U-elements, twenty-one LB fragments, and five LA-elements. The LA-elements have a broad basal cavity that is distinctively different from the LA-elements of E. triassica. The lateral processes on the U-element encompass an angle just short of 180°, whereas the U-elements in E. triassica encompass an angle of just over 90°. White matter is uniformly distributed in triassica elements but is generally lacking in elements of E. festiva.

Occurrence: Pinery Limestone, West Texas; Gerster Fm. Nevada; Rupe del Passo di Burgio, Sicily (Middle Permian).

Ellisonia tribulosus (Clark and Ethington), 1962

Pl. 2, Figs. 13-20; Pl. 3, Figs. 1-2

Apatognathus tribulosus Clark and Ethington, 1962

Pl. 1, Fig. 3, 7, 13, 17

Lonchodina mulleri Tatge, Clark and Ethington, 1962,

Pl. 1, Fig. 4

Hindeodella sp. b Bender and Stoppel, 1965,

Pl. 15, Fig. 7

Description: A species of Ellisonia with a skeletal apparatus composed of U, LA1, LA2, LB1, LB2, and LC elements. White matter occurs as distinctive bands around blades or as irregular cloudy masses.

LC-elements have two denticulated anterolateral processes of unequal length that are continuous with costae on the cusp. These processes are deflected laterally in such a way as to present a distinct "V" shape from a superior or inferior view. One denticle is commonly at least half the length of the cusp. The cusp is semi-triangular in cross section. No basal pit is evident. Lateral attachment surfaces are visible.

LA1-elements have a rounded to subtriangular shape in cross section, with two denticulated anterolateral processes of unequal length. Each process bears from three to five denticles. The banding of white matter is particularly distinctive in these elements. The posterior, inferior surface flares to form a distinct lip. A reduced basal pit can be seen in younger specimens.

LA2-elements can be easily separated from LA1-elements even though intermediate forms occur in some samples. These elements also have rounded to subtriangular denticles. They bear two anterolateral processes, one with three to five denticles. The other process is commonly undenticulated, or contains one to three "protodenticles." The posterior, inferior lip is less pronounced, and the entire element presents a more flattened appearance.

LB1-elements bear an erect cusp and a short posterior process. The anterior process is deflected laterally and downward. Denticles are laterally compressed. Denticles increase in length toward the cusp from the anterior extremities.

LB2-elements are very similar to LB1-elements. The anterior process becomes bifid and bears one to two denticles. In some forms the cusp is reduced in size and blends with the other denticles.

U-elements are symmetrical with a denticulated posterior process, and two denticulated anterolateral processes. The cusp and the anterolateral processes describe a smooth curve from a lateral view. The lateral processes bear an average of five laterally compressed denticles, and are continuous with costae on the cusp.

Remarks: The frequency of occurrence and numbers of E. tribulosus elements are closely related to those of E. gradata Sweet, which is clearly a distinct species (see Sweet, 1970).

Occurrence: Pinery Limestone Member Brushy Canyon Formation, West Texas; Meade Peak Member Phosphoria Formation, Coal Canyon, Wyoming, and Idaho; Rupe de Passo di Burgio, Sicily.

Genus Neogondolella Bender and Stoppel, 1965

Type species, Gondolella mombergensis Tatge, 1956.

The skeletal apparatus of Neogondolella consists of dextral and sinistral elements of a single morphologic type. These elements consist of a posterior cusp and a long denticulated anterior carina that is separated by furrows from platforms that flank the elements laterally. The platform is pitted on the upper surface. A keel with a basal groove extends along the under surface and ends in a basal pit beneath the cusp.

Neogondolella ranges from Lower Permian (Upper Wolfcampian, after faunal crisis) to late Middle Triassic (N. bisselli was the first Neogondolella species). Neogondolella species were very probably descendants of the Pennsylvanian and Early Permian genus Gondolella, of which G. bella is the youngest species known.

Representatives of Neogondolella differ from those of Gondolella in several ways. The surface of Neogondolella elements is finely to coarsely pitted and the platform continues on around the posterior end of the elements, enclosing the cusp and forming a distinct rim in mature specimens. In elements of some species this rim is projected downward to the basal loop as a buttress-like structure.

The surface of Gondolella elements is smooth to glassy and the platform is continuous with the lateral edges of the cusp: it does not extend around the posterior side of the cusp. In addition, the entire surface of the platform is sculptured with ridges and crenulations, whereas, elements of only a few Neogondolella species seem to show this characteristic. Reduction of ornamentation seems to be an evolutionary trend. The basal groove in Gondolella elements is thin, deep, and flanked by elevated ridges that form a prominent flared loop around the basal pit. Neogondolella elements have a broad, trough-like basal groove with flared edges in earlier forms (e.g., N. bisselli). Later forms have a reduced basal groove (only a line), with a basal pit that is surrounded by an elevated flange (most Triassic forms) (see Clark and Mosher, 1966).

<u>Neogondolella</u> sp. <u>c</u> Croft,

Pl. 3, Fig. 10-11, 17-20; Text Fig. 8

<u>Diagnosis</u>: A species of <u>Neogondolella</u> with dextral, sinistral and subsymmetrical arched elements. The platform is broad and pitted on the superior surface. The element bears a carina with well-developed lateral furrows that separate it from the platform. The denticles are sharp in juvenile-stage specimens but become increasingly more nodose and filled-in in elements that represent mature and gerontic stages. White matter tends to fill in around denticles of the carina in mature-stage specimens. The denticles tend to increase in length at the anterior end of the carina and are fused and laterally compressed to varying degrees. A short free blade is developed anteriorly in most specimens. The cusp is commonly overgrown and reduced in gerontic-stage specimens. Mature specimens average 15 to 18 denticles. One specimen was observed to have 19 denticles. The platform is widest at a point one-third of the distance anteriorly from the cusp. The keel is broad with lateral ridges. The basal groove is thin and becomes reduced in mature specimens. It terminates posteriorly beneath the cusp in a basal pit with a raised flange, which tends to be reduced in older specimens. This flange is surrounded by a non-flaring loop.

Elements grow by adding material to the anterior end of the platform (Pl. 3, Fig. 3). The platform does not extend around the cusp in juvenile specimens (Text Fig. 8). This characteristic is preserved quite late in juvenile and intermediate-sized specimens. In larger specimens the platform extends posteriorly around the cusp in a distinct brim, which is projected downward in a buttress-like structure to the loop around the flange and basal pit. A slight "notch" commonly occurs on the platform of asymmetrical units.

Remarks: Numbers of specimens and frequencies are listed in Table 1, 3. Neogondolella sp. c Croft has elements that are broader, and have a more highly pitted surface than elements of N. idahoensis. N. idahoensis elements also taper from a wide point at the posterior end of the element. N. rosenkrantzi, which was described from the Posidonia Shale of Greenland, and is thus younger than N. sp. c, also has elements that taper from a widest point at the posterior end of the element. N. rosenkrantzi elements lack a free blade and have a flat, filled-in platform with reduced lateral furrows.

Neogondolella sp. c subsp. sc Croft,

Pl. 3, Figs. 3-9, 12-16; Text Fig. 8

Diagnosis: A subspecies of Neogondolella with elements that resemble those of N. sp. c Croft. Intermediate forms are found in most samples making tabulation difficult. Both forms are identical in early growth stages (Text Fig. 8 and 9). However, serrations begin to appear along the edges of the platform as N. sp. c subsp. sc elements grow, whereas intermediate forms of N. sp. _c_ develop furrows on the superior surface of the platform but no serrations are formed along the edges. The denticles tend to be more discrete in elements of N. sp. _c_ subsp. _sc_ than in N. sp. _c_ elements. In addition, the carinal furrows tend to be more pronounced. The cusp is slightly larger in many specimens than the other posterior denticles. Serrations occupy the anterior third of the carina.

Remarks: Frequency and numbers of specimens are listed in Table1, 3. Elements of this subspecies are distinct from those of *N. serrata* (Clark and Ethington) since *serrata* elements bear furrows on the anterior half of the platform, which may extend over the edges to the posterior surface. The under surface of N. sp. _c_ sc. is smooth and glassy. It appears that reduction of serrations tends to be an evolutionary trend.

Occurrence: The Pinery Limestone Member of the Bell Canyon Formation, West Texas.

Genus *Prioniodella* Bassler, 1925

Type species, *Prioniodella normalis*, Bassler, 1925.

Sweet (1970) used this name in a form-generic sense for blades with laterally compressed denticles that are partially fused at their base, but particularly at mid-height so as to give the element a markedly swollen appearance. The blade has a small basal pit. Sweet suggested that the genus contains a variety of different things and used the name with reservation. The author realizes the difficulties inherent in using this generic name. In the interests of presenting a complete report on the Permian conodonts collected, the author has tentatively assigned the following two types of elements to Prioniodella. These may in fact be parts of a multi-element Ellisonia-type apparatus. That is, they may be the posterior process, or the bifid processes of an LB2-element.

Prioniodella ? sp. 1,

Pl. 2, Figs. 1, 2

Diagnosis: A form species of Prioniodella ? with laterally compressed, blade-like denticles, which are discrete. The element is long and sinuous and bears no basal pit. White matter is absent and the element ranges from golden to amber in color. Denticle length decreases from the center of the element to the distal ends. One end of the element appears to be broken and lacking several denticles.

Remarks: Elements of this sort may well be fragments of Ellisonia-type elements. The author's material contains 12 specimens.

Occurrence: Pinery Limestone Member of Bell Canyon Formation, West Texas.

Prioniodella ? sp. 2,

Pl. 2, Figs. 3, 4

Diagnosis: A form species of Prioniodella ? with laterally compressed denticles that are fused for the lower third of their length, but more so at mid-height so as to give the element a somewhat swollen appearance. Many specimens are complete and unbroken, have no basal pit, and have white matter distributed in a line down the center of each denticle from the apex. Elements are golden to amber in color.

Remarks: The author's material contains 41 specimens. These may be parts of an Ellisonia-type apparatus. Identical material was examined by the author from a sample loaned to him by Dr. Walter Sweet and collected from the Pipeline Shale Member of the Brushy Canyon Formation (Lower Wordian).

Occurrence: Pinery Limestone Member of the Bell Canyon Formation; Pipeline Shale Member of the Brushy Canyon Formation.

Genus Xaniognathus Sweet, 1970

Type species, Xaniognathus curvatus Sweet.

Elements of these genus are dextral and sinistral, laterally compressed, blade-like structures. The cusp is longer than any of the denticles. Each element bears a long denticulated anterior process with lateral ribs and a short posterior process with no lateral ribs. These processes have basal grooves, which terminate in a basal pit beneath the cusp.

Sweet (1970) originally proposed the genus to include several Lower Triassic species (X. curvatus, X. deflectens, X. elongatus). The author includes his material (identified as X. abstractus (Clark and Ethington)) because it is obviously related to the Lower Triassic species.

Xaniognathus abstractus (Clark and Ethington), 1962, Pl. 1, Fig. 11-13

Subbryantodus abstractus Clark and Ethington, 1962, P. 112, Pl. 1-2, Fig. 16, 20-21, 2

? Ozarkodina tortilis Tatge--Bender and Stoppel, 1965, P. 348-349, Pl. 15, Fig. 16a, b, 17

Diagnosis: A species of Xaniognathus with elements consisting of a long denticulated anterior process and a short denticulated posterior process, which contains from one to six denticles. The anterior process contains from six to eleven denticles. The posterior process is laterally deflected giving the element a lateral bow at the cusp. Denticles are discrete for only the upper one-half to one-third of their length and are all directed posteriorly. Both processes have basal grooves that terminate in a basal pit below the cusp.

The elements range in color from golden to dark amber and are mostly translucent. White matter is lacking in most elements, but in those that contain white matter it is distributed as bands across individual denticles, or as a shadowy haze.

Remarks: The author's collections contain 352 dextral and sinistral elements. *X. abstractus* elements are commonly associated with those of *E. tribulosus* (Clark and Ethington), but they do not appear to be members of the same multi-element species since *X. abstractus* elements occur in samples that contain no Ellisonia elements (see frequency charts, Table 3).

Occurrence: Brushy Canyon Formation and Pinery Limestone Member of Bell Canyon Formation, West Texas; Meade Peak Member, Phosphoria Formation, Idaho, Wyoming.

PLATE 1

All figures are slightly retouched photographs of uncoated specimens, x 100.

Figures:

1-3. Anchignathodus sp.? ___a___ Croft, 1, 2, Lateral views; 3, Superior view (72 PLM-15), samples 71SA-12 (Cibolo Fm.), 72 PLM-15.

4-10. Anchignathodus sp. ___b___ Croft, 4, 7-10, Lateral views; 5, Lateral view, very mature specimen; 6, Superior view, very mature specimen, sample 72 PLM-18a.

11-13. Xaniognathus abstractus (Clark and Ethington), 11, 12, 13, Lateral views, sample 72 PLM-18a.

14-16. Ellisonia festiva (Bender and Stoppel) aff. E. triassica Muller, 14, Lateral view LB-element; 15, Superior view U-element; 16, Lateral view U-element; Sample 72 PLM-18a.

PLATE 1

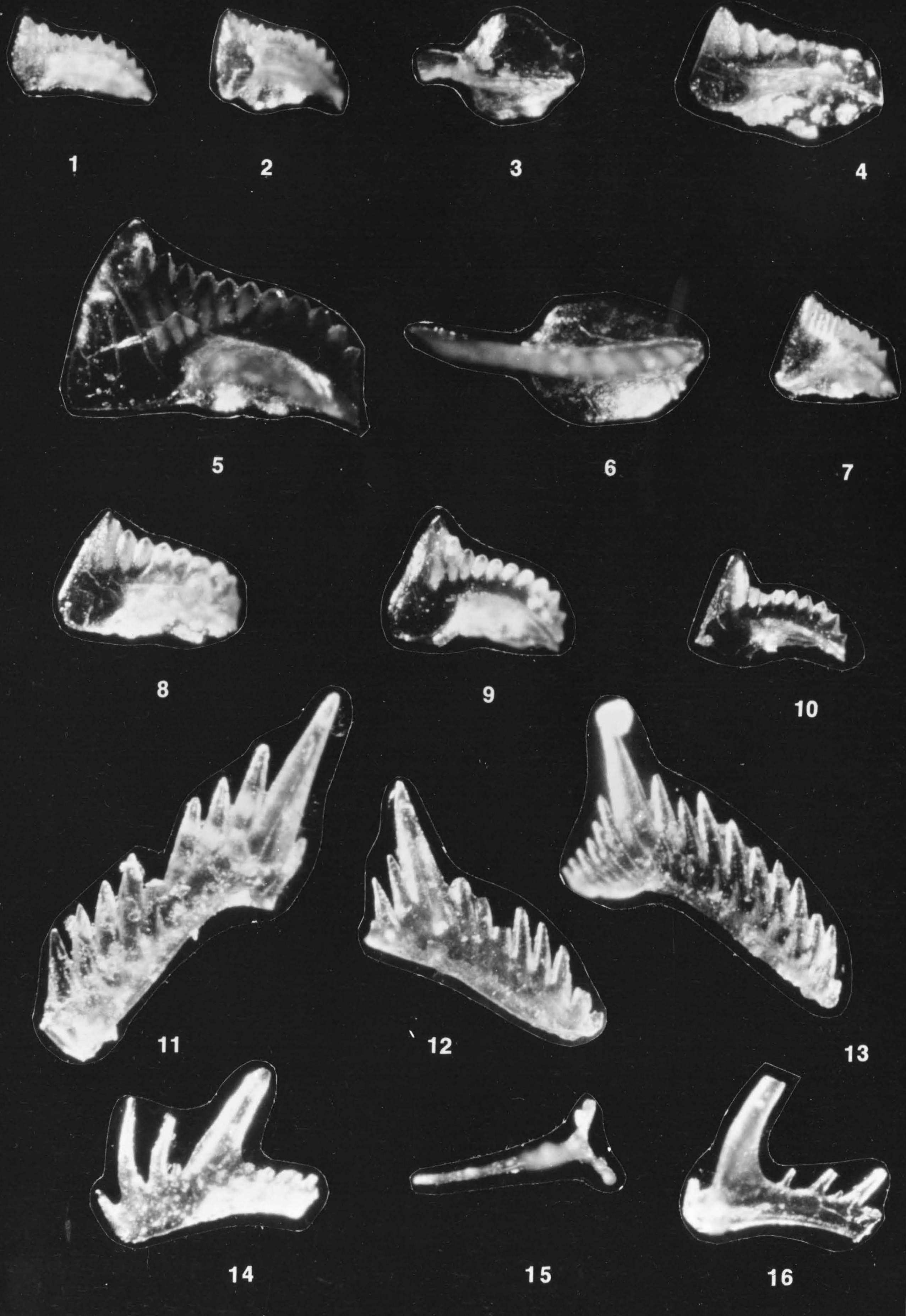


PLATE 2

All figures are slightly retouched photographs of uncoated specimens. Figures are x 100 except 5-7 which are x 50.

Figures:

1-2. Prioniodella ? sp. 1; Lateral view; 2, Superior view, sample 72 PLM-9.

3-4. Prioniodella ? sp. 2; 3-4, Lateral views, sample 72 PLM-18a.

5-8. Ellisonia festiva (Bender and Stoppel) aff. E. triassica Muller; 5, Lateral view LA-element; 6-7, Lateral view LB-element; 8, Lateral view U-element, sample 72 PLM-19.

9-12. Ellisonia sp. t Croft, aff. E. teicherti Sweet; 9, Lateral view LA-element, 72 PLM-18a; 10, Lateral view LB-element, 72 PLM-9; 11-12, Lateral view LB-element, 72 PLM-18a.

13-20. Ellisonia tribulosus (Clark and Ethington) aff. E. gradata Sweet; 13, Anterior view LC-element, 72 PLM-19; 14, Posterior view LC-element, 72 PLM-19; 15, Posterior view LA2-element, 72 PLM-18a; 16-17, Posterior view LA-element, 72 PLM-18a; 18, Lateral view LB-element, 72 PLM-19; 19, Superior view LB2-element, 72 PLM-19; 20, Lateral view LB2-element, 72 PLM-19.

PLATE 2

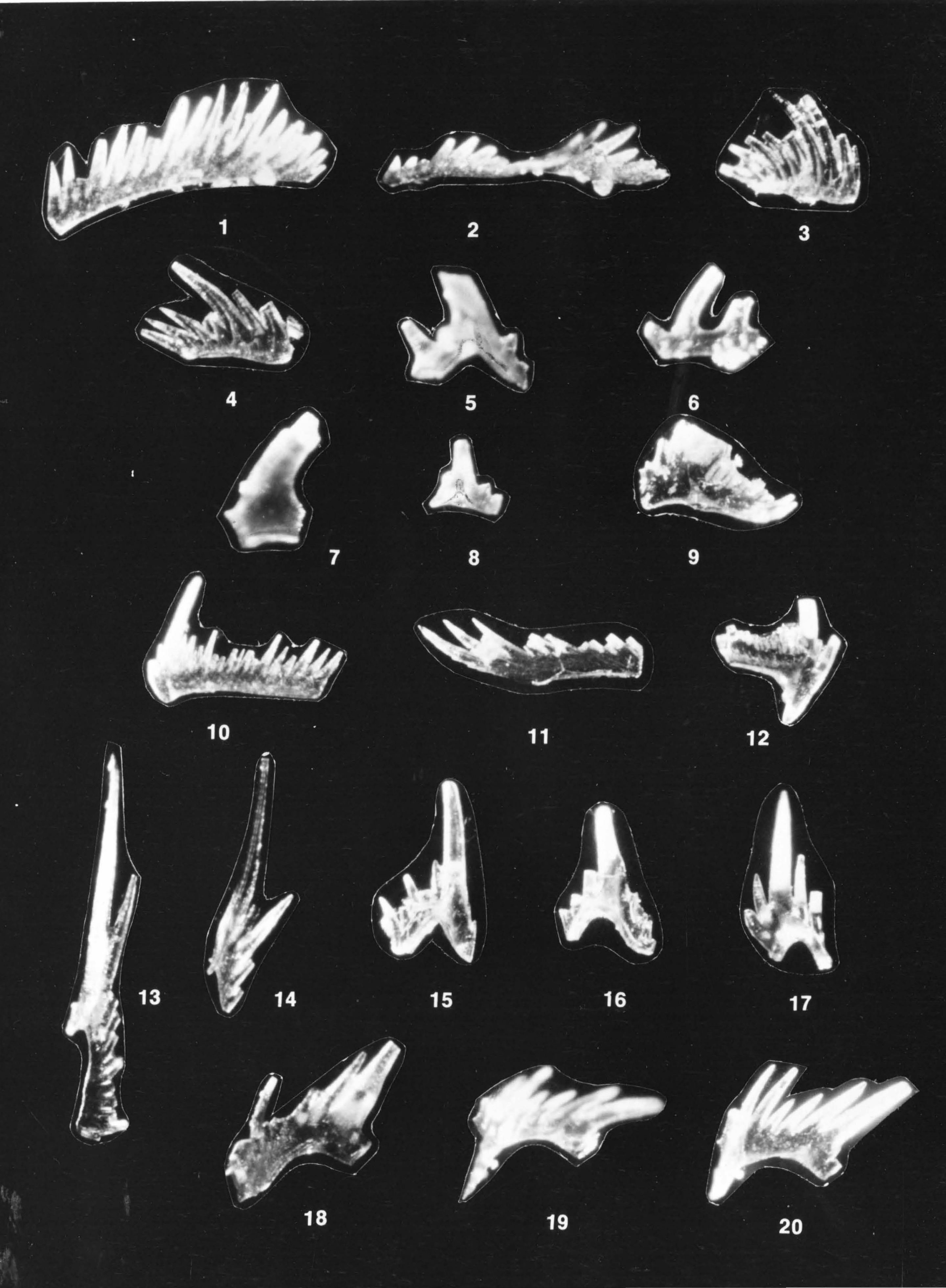


PLATE 3

All figures are slightly retouched photographs of uncoated specimens. All figures are x 100 except 10-20 which are x 50.

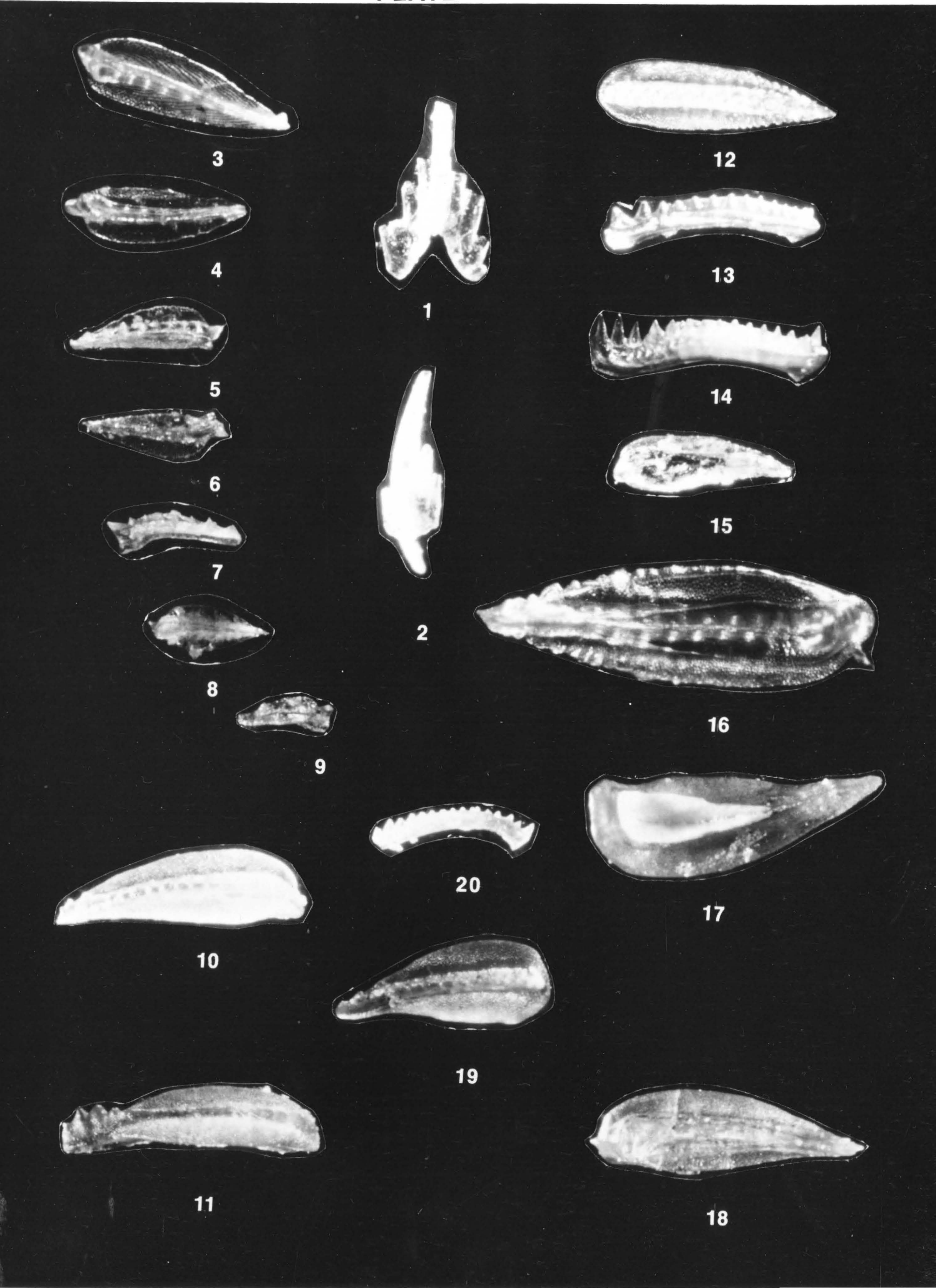
Figures:

1-2. Ellisonia tribulosus (Clark and Ethington) aff. E. gradata Sweet; 1, Posterior view U-element, 72 PLM-19; 2, Lateral view U-element, 72 PLM-19.

3-9, 12-16. Neogondolella sp. ___c___ subsp. ___sc___ Croft; 3-9, Superior and inferior views of ontogenetic growth series, samples 72 PLM-18a, 72 PLM-31; 12-16, Superior and inferior views of ontogenetic growth series, samples 72 PLM-18a, 72 PLM-31.

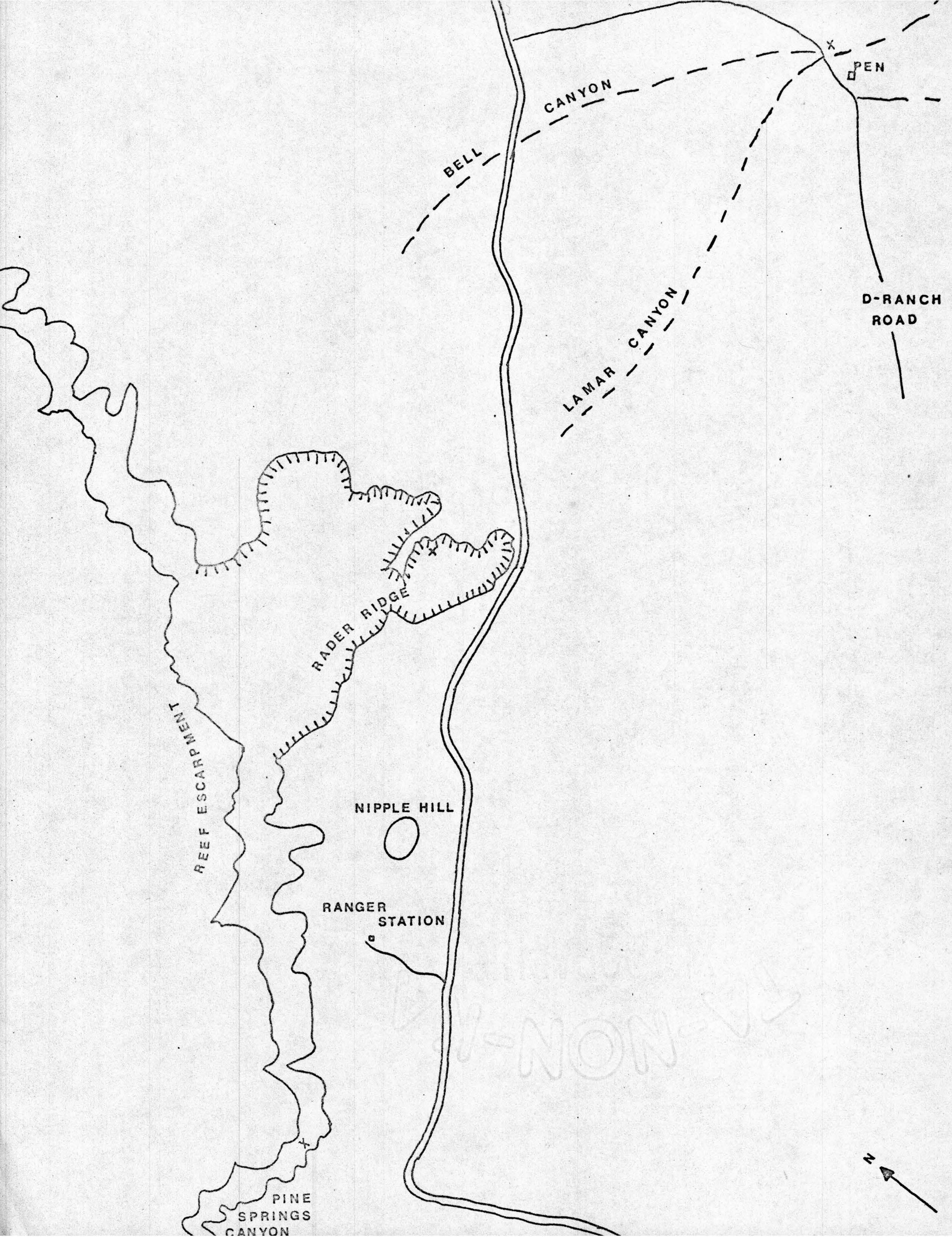
10-11, 17-20. Neogondolella sp. ___c___ Croft; 10-11, 17-20, Superior, inferior, and lateral views, samples 72 PLM-15, 72 PLM-24, 72 PLM-25, 72 PLM-27.

PLATE 3



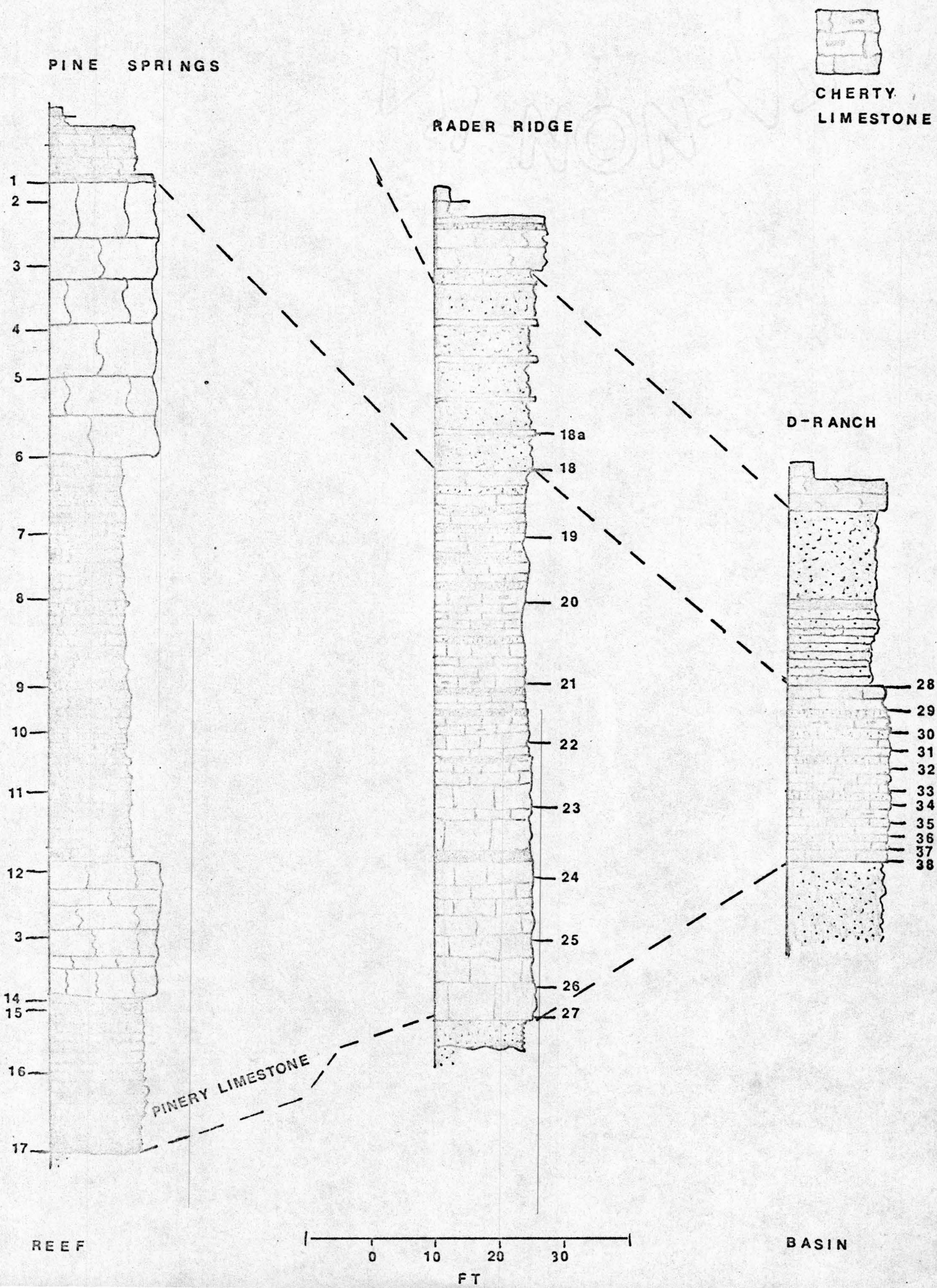
TEXT FIGURE 1

A generalized map of the area of this report. Sections were measured and sampled at places marked "X." (Refer to maps section for scale and reference.)


PEN
BELL CANYON
LAMAR CANYON
D-RANCH ROAD
RADER RIDGE
REEF ESCARPMENT
NIPPLE HILL
RANGER STATION
PINE SPRINGS CANYON
N

TEXT FIGURE 2

A diagram illustrating the sections studied. The lithologies and the sample intervals are also shown.

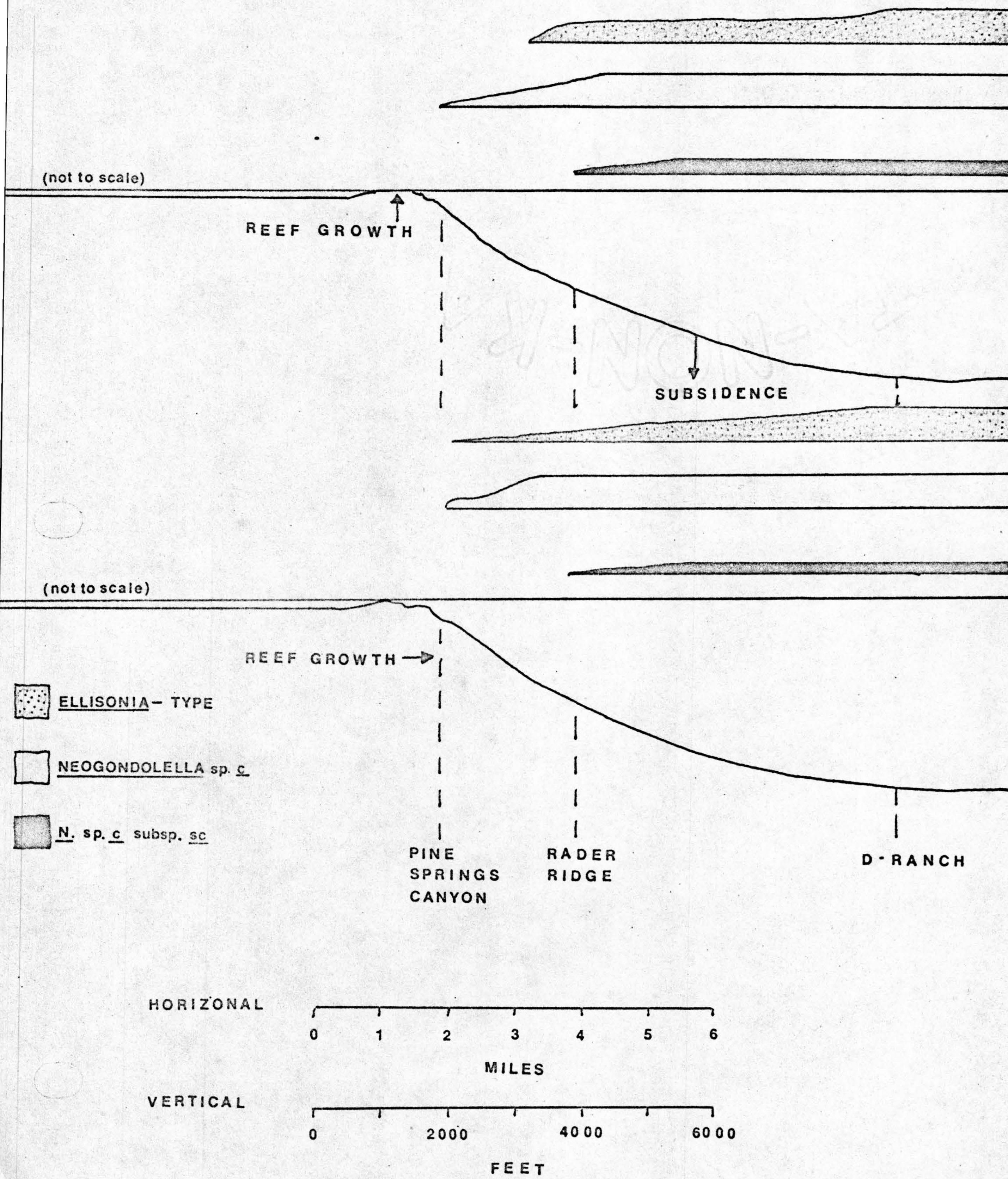


PINE SPRINGS
RADER RIDGE
D-RANCH
CHERTY LIMESTONE
1
2
3
4
5
6
7
8
9
10
11
12
3
14
15
16
17
18a
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
PINERY LIMESTONE
REEF
BASIN
0
10
20
30
FT

TEXT FIGURE 3

An interpretation of the horizontal and vertical distribution of conodont faunas during the period of deposition of the Pinery Limestone Member of the Bell Canyon Fm.

TEXT FIGURE 3



TEXT FIGURES 4-6

"A" is a graph of the percents of the Ellisonia-type fauna versus the percents of the two Neogondolella species.

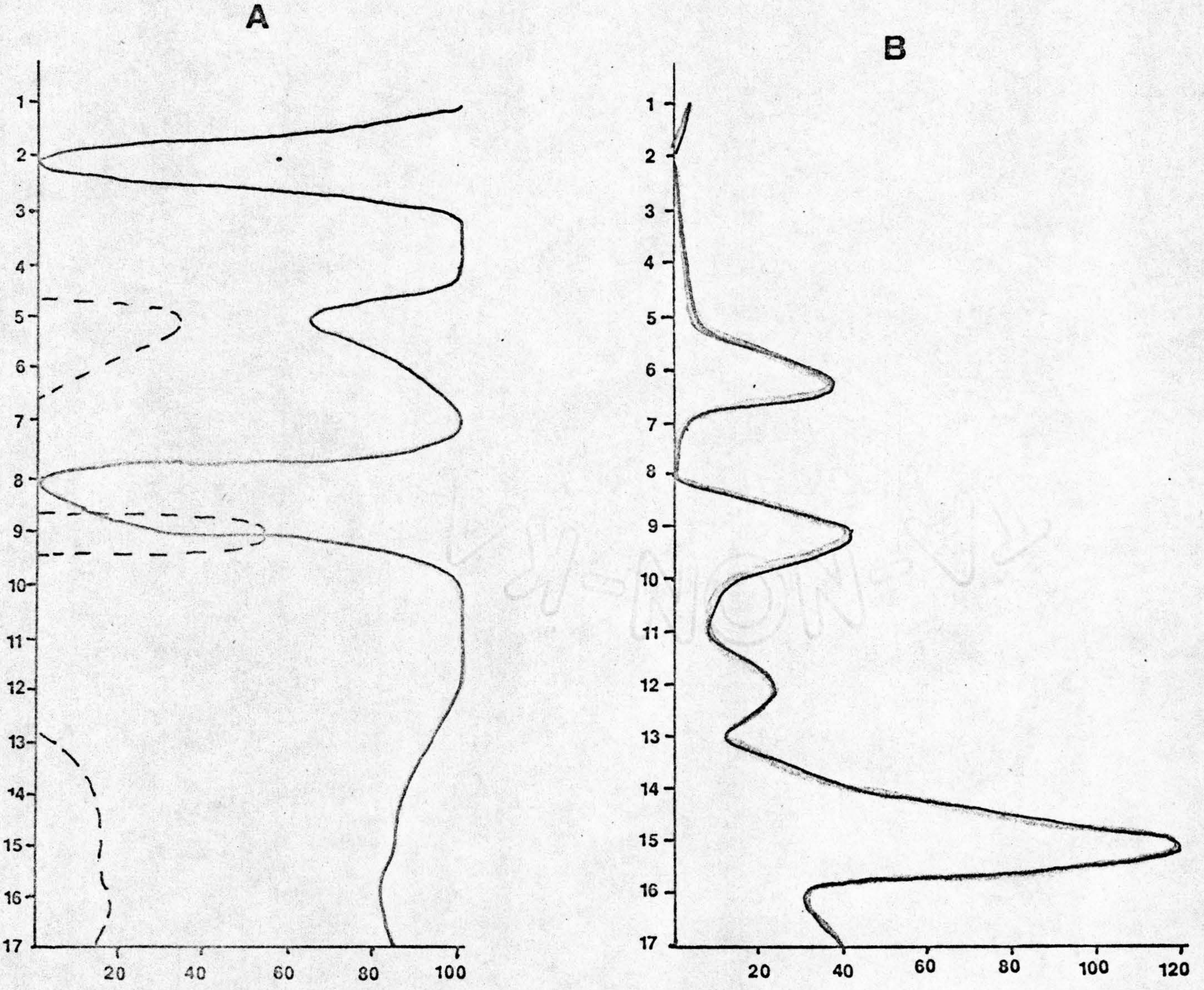
"B" is a graph of the total numbers of conodonts per sample.

Figure:

4.	Pine Spring Canyon Section.
5.	Rader Ridge Section.
6.	D-Ranch Section.

FIG. 4

PINE SPRINGS CANYON



PERCENTAGES

NUMBER OF CONODONTS PER SAMPLE

——— NEOGONDOLELLA sp. c

– – – – ELLISONIA-TYPE

FIG. 5

RADER RIDGE

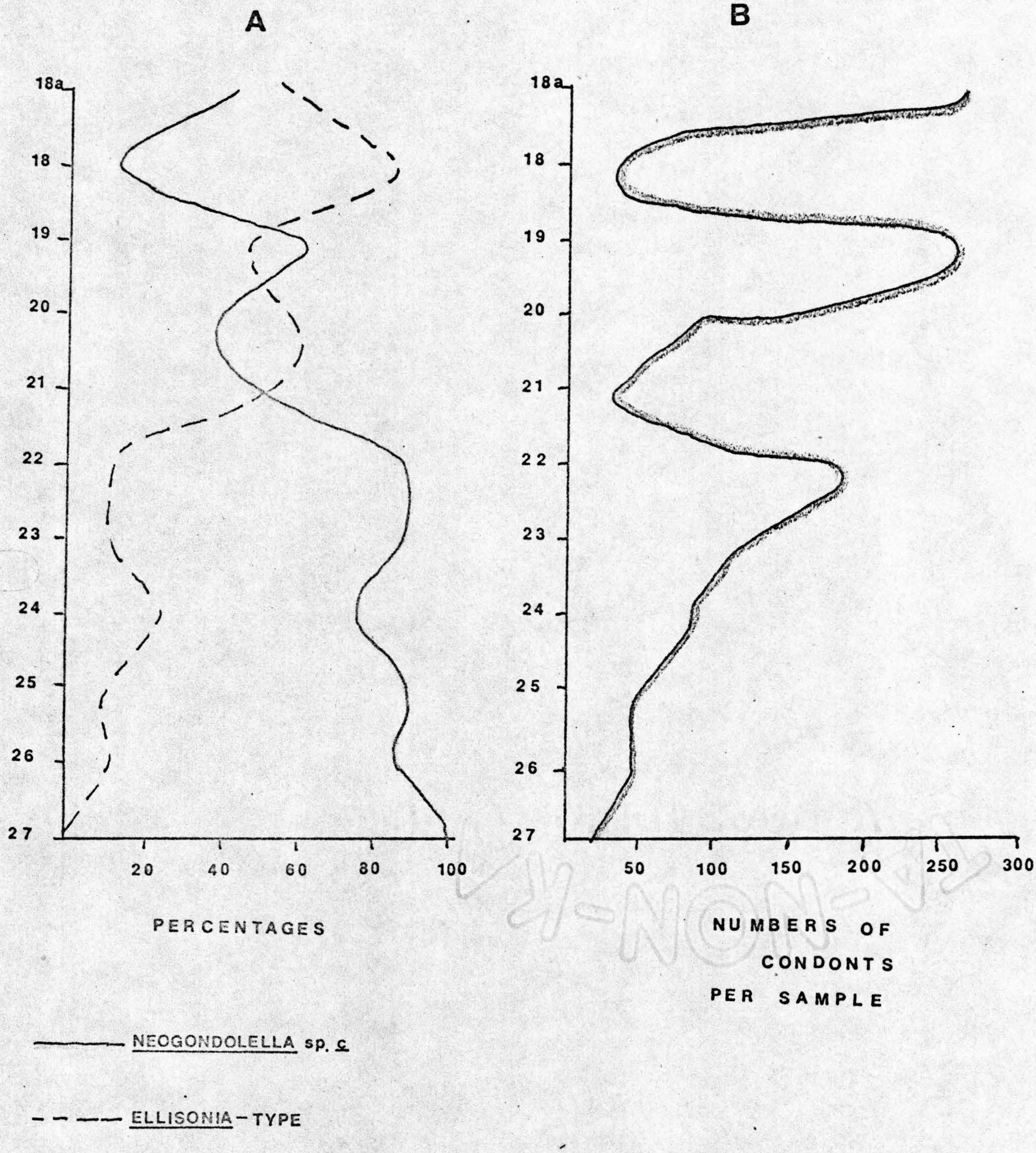
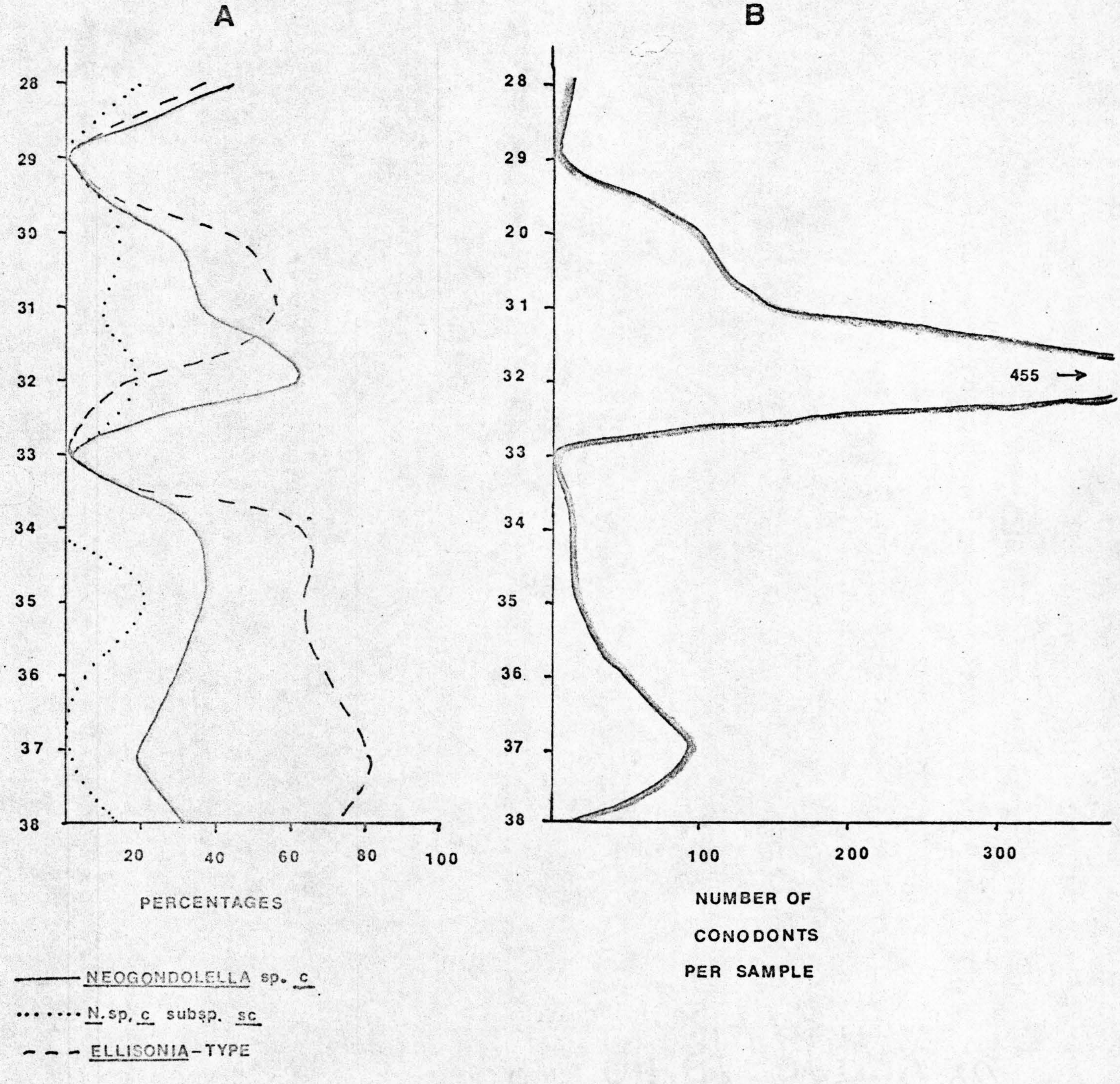


FIG. 6

D — RANCH


A
B
28
29
30
31
32
33
34
35
36
37
38
28
29
20
31
32
33
34
35
36
37
38
20
40
60
80
100
PERCENTAGES
455
100
200
300
NUMBER OF
CONODONTS
PER SAMPLE
NEOGONDOLELLA sp. c
N. sp. c subsp. sc
ELLISONIA-TYPE

TEXT FIGURE 7

An illustration of proposed evolutionary trends in the genus Anchignathodus. The trend is toward enlargement of the delta-shaped cusp, enlargement of the denticles and a general elongation of the element.

Figure:

A. Anchignathodus minutus (Ellison)

A. Lateral view and generalized outline.

(Upper carboniferous)

B-C. Anchignathodus sp. a Croft, n. sp.

B-C. Lateral view and generalized outline.

(Wordian, Lower Guadalupian)

D. Anchignathodus sp. b Croft, n. sp.

D. Lateral view and generalized outline.

(Lower Guadalupian)

E. Anchignathodus julfensis Sweet

E. Lateral view and generalized outline.

(Uppermost Permian)

F. Anchignathodus typicalis Sweet

F. Lateral view and generalized outline.

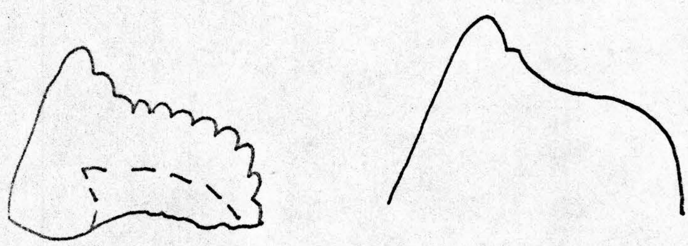
(Uppermost Permian to Lower Triassic)

A

B

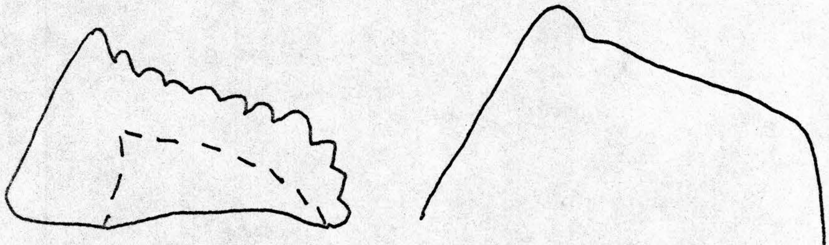
C

D



E

F



TEXT FIGURE 8

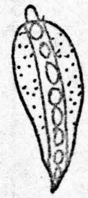
Figures:

A-I. Neogondolella sp. ___c___ Croft, n. sp.

A-I. Ventral, lateral and dorsal view of elements representing three growth stages.

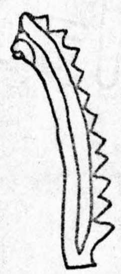
A

B

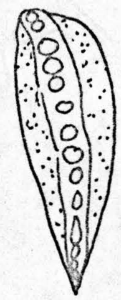


C

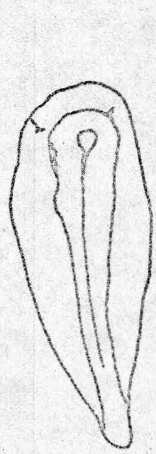
D



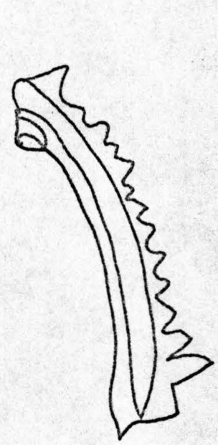
E



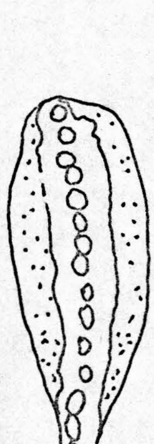
F



G



H



I

TEXT FIGURE 9

Figures:

A-C. Neogondolella sp. c, subsp. sc Croft.

A-C. Lateral, upper, and lower views (note serrations not yet developed).

D-O Neogondolella sp. c, subsp. sc Croft.

D-O. Views of elements (note development of serrations).

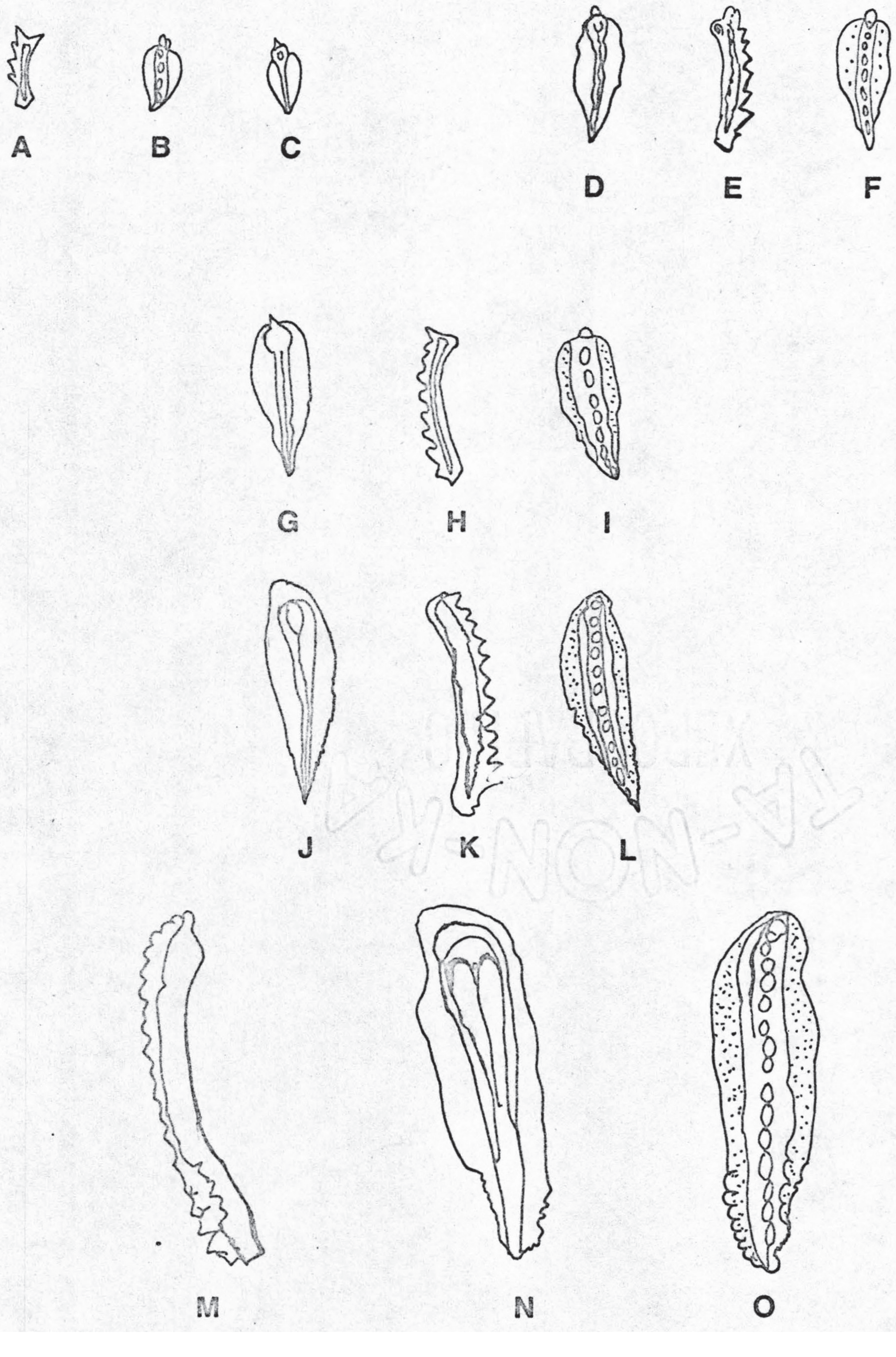

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O

TABLE 1

Distribution of Conodonts Collected	N. sp. c	N. sp. c subsp. sc	A. sp. b	A? sp. a	X. abstractus	P? sp. 1	P? sp. 2	E. sp. t		E. festiva				Total
								LB	LA	U	LB	LA	LF	
72 PLM-1	3													3
72 PLM-2					Barren									0
72 PLM-3	1													1
72 PLM-4	2													2
72 PLM-5	3										2			5
72 PLM-6	49		1		2									52
72 PLM-7	3				8									11
72 PLM-8					Barren									0
72 PLM-9	28		3			3	1	1						36
72 PLM-10	6													6
72 PLM-11	6													6
72 PLM-12	23													23
72 PLM-13	8				1									9
72 PLM-14	26			1	3				1		1			32
72 PLM-15	83			1	13									97
72 PLM-16	40				8									48
72 PLM-17	48				5									53
72 PLM-18a	103	9	23		32	8		4	1		1		1	182
72 PLM-18	4		11		4		1	2	1					23
72 PLM-19	216		8		37	2				1	4	2		270
72 PLM-20	47		22		17	2					1			89
72 PLM-21	16		5		9						4			34
72 PLM-22	113		1		12						1	1		128
72 PLM-23	122				10						2			134
72 PLM-24	72				17			1						90
72 PLM-25	64		1		2						1			68
72 PLM-26	44				4						1			49
72 PLM-27	15													15
72 PLM-28	7	3			3									13
72 PLM-29					3	1	1							5
72 PLM-30	40	19	1		30		1				1	1		93
72 PLM-31	68	24			38	5	1	1						137
72 PLM-32	406	134			32	1					3	1		580
72 PLM-33					Barren									0
72 PLM-34	5				4									9
72 PLM-35	10	6			4	1								21
72 PLM-36	16	7			14	4	1	2						44
72 PLM-37	24	2			34	11	5				1			77
72 PLM-38	8	3			6		1							18

TABLE 2

Normalized Conodonts/ KG	N. sp. c	N. sp. c subsp. sc	A. sp. b	A? sp. a	X. abstractus	P? sp. 1	P? sp. 2	E. sp. t		E. festiva			Total
								LB	LA	LB	LA	U	
72 PLM-1	3												3
72 PLM-2													0
72 PLM-3	1												1
72 PLM-4	2												2
72 PLM-5	4								2				6
72 PLM-6	33		1		2								36
72 PLM-7	3												3
72 PLM-8													0
72 PLM-9	19		2		6	3	1	1					32
72 PLM-10	13												13
72 PLM-11	8												8
72 PLM-12	23												23
72 PLM-13	12				1								13
72 PLM-14	44			1	5					1			51
72 PLM-15	100			1	16								117
72 PLM-16	27				6								33
72 PLM-17	32				4								36
72 PLM-18a	92	7	20		28	7		3	1	1			163
72 PLM-18	4		10		4		1	2	1				22
72 PLM-19	166		6		28	2				3	2	1	208
72 PLM-20	32		15		11	2				1			61
72 PLM-21	14		4		8					3			29
72 PLM-22	162		1		17					1	1		182
72 PLM-23	98				8					3			109
72 PLM-24	61				14			1					76
72 PLM-25	43		1		2					1			47
72 PLM-26	40				4					1			45
72 PLM-27	13												13
72 PLM-28	5	2			2								9
72 PLM-29					2	1	1						4
72 PLM-30	28	12	1		20		1			1	1		64
72 PLM-31	48	17			27	4	1	1					98
72 PLM-32	248	94			22	3				3			371
72 PLM-33													0
72 PLM-34	4				3								7
72 PLM-35	7	4			3	1							15
72 PLM-36	13	2			9	3	1	2					30
72 PLM-37	17	1			23	7	4						52
72 PLM-38	5	2			4		1						12

TABLE 3

Distribution and Frequency of Elements

ACTUAL COUNTS — NORMALIZED TO CONODONTS / KG.

ELLISONIA tribulosus (CLARK and ETHINGTON)

	Actual counts							Normalized to conodonts / kg.						
	U	LA1	LA2	LB1	LB2	LC	Total	U	LA1	LA2	LB1	LB2	LC	Total
72 PLM-1														
72 PLM-2			BARREN				0			BARREN				
72 PLM-3														
72 PLM-4														
72 PLM-5														
72 PLM-6						1							1	1
72 PLM-7														
72 PLM-8			BARREN				0			BARREN				
72 PLM-9		1		2	3	2	8		1		2	4	2	9
72 PLM-10														
72 PLM-11														
72 PLM-12														
72 PLM-13														
72 PLM-14														
72 PLM-15	1					1	2	1					1	2
72 PLM-16														
72 PLM-17	2						2	2						2
72 PLM-18a	14	22	14	13	8	28	99	12	19	12	11	7	25	86
72 PLM-18	1	3		5		1	10	1	3		4		1	9
72 PLM-19	8	3	7	1	10	21	50	7	3	21	1	8	16	56
72 PLM-20	1	5	5	4	14	4	33	1	3	3	3	9	3	22
	U	LA1	LA2	LB1	LB2	LC	Total	U	LA1	LA2	LB1	LB2	LC	Total
72 PLM-21						1	1						1	1
72 PLM-22														
72 PLM-23						2	2						2	2
72 PLM-24			1			5	6			1			4	5
72 PLM-25			1				1			1				1
72 PLM-26														
72 PLM-27						1	1							
72 PLM-28				2		2	4				1		1	2
72 PLM-29		1					1		2					2
72 PLM-30	1	6	7	1	7	22	44	1	4	5	1	5	15	31
72 PLM-31	4	8	9	3	6	26	56	3	13	6	2	4	18	46
72 PLM-32	2	10	13	4	12	29	70	1	7	9	3	8	20	48
72 PLM-33			BARREN				0			BARREN				0
72 PLM-34		3		1		2	6		2		1		1	4
72 PLM-35	2	1	1			2	6	1	1	1			1	4
72 PLM-36		5	3	2	9	16	35		3	2	1	6	11	23
72 PLM-37	5	7	11	4	1	22	50	3	5	7	3	7	15	40
72 PLM-38		3		1	2	5	11		2		1	1	3	7

REFERENCES

Bassler, R. S., 1925. Classification and Stratigraphic Use of Conodonts. G.S.A. Bull., v. 36, p. 218-220.

Bender, Hans, and Stoppel, Dieter, 1965. Perm-Conodonten: Geol. Jahrb., Bd. 82, p. 331-334, pl. 14-16.

Clark, D. L., and Ethington, R. L., 1962. Survey of Permian Conodonts in western North America: Brigham Young Univ. Geol. Studies, v. 9, part 2, p. 102-114, pl. 1-2.

________, Mosher, L. C., 1966. Stratigraphic, geographic, and evolutionary development of the conodont genus Gondolella. Jour. Paleontology, v. 40, n. 2, pp. 376-394, pl. 45-47.

________, 1972. Early Permian crisis and its bearing on Permo-Triassic conodont taxonomy. Geologica et Paleontologica, SB. 1, pp. 147-158.

Kendall, C. G. St. C., 1969. An Environmental Reinterpretation of the Permian Evaporite/Carbonate Shelf Sediments of the Guadalupe Mts. Geol. Soc. Am. Bull., v. 80, pp. 2503-2526.

King, Philip B., 1942. Permian of West Texas and Southeastern New Mexico. The American Assoc. of Petroleum Geologists, Tulsa.

________, 1948. Geology of the Southern Guadalupe Mts., Texas, U.S.G.S. Prof. paper 215.

Lindstrom, Maurits, 1964. Conodonts, New York, Elsevier Publishing Co.

Newell, N. D., and others, 1953. The Permian Reef Complex of the Guadalupe Mts. Region, Texas and New Mexico, W. H. Freeman and Co., San Francisco.

Odum, Eugene P., 1971. Fundamentals of Ecology. W. B. Sanders and Co., p. 329-342.

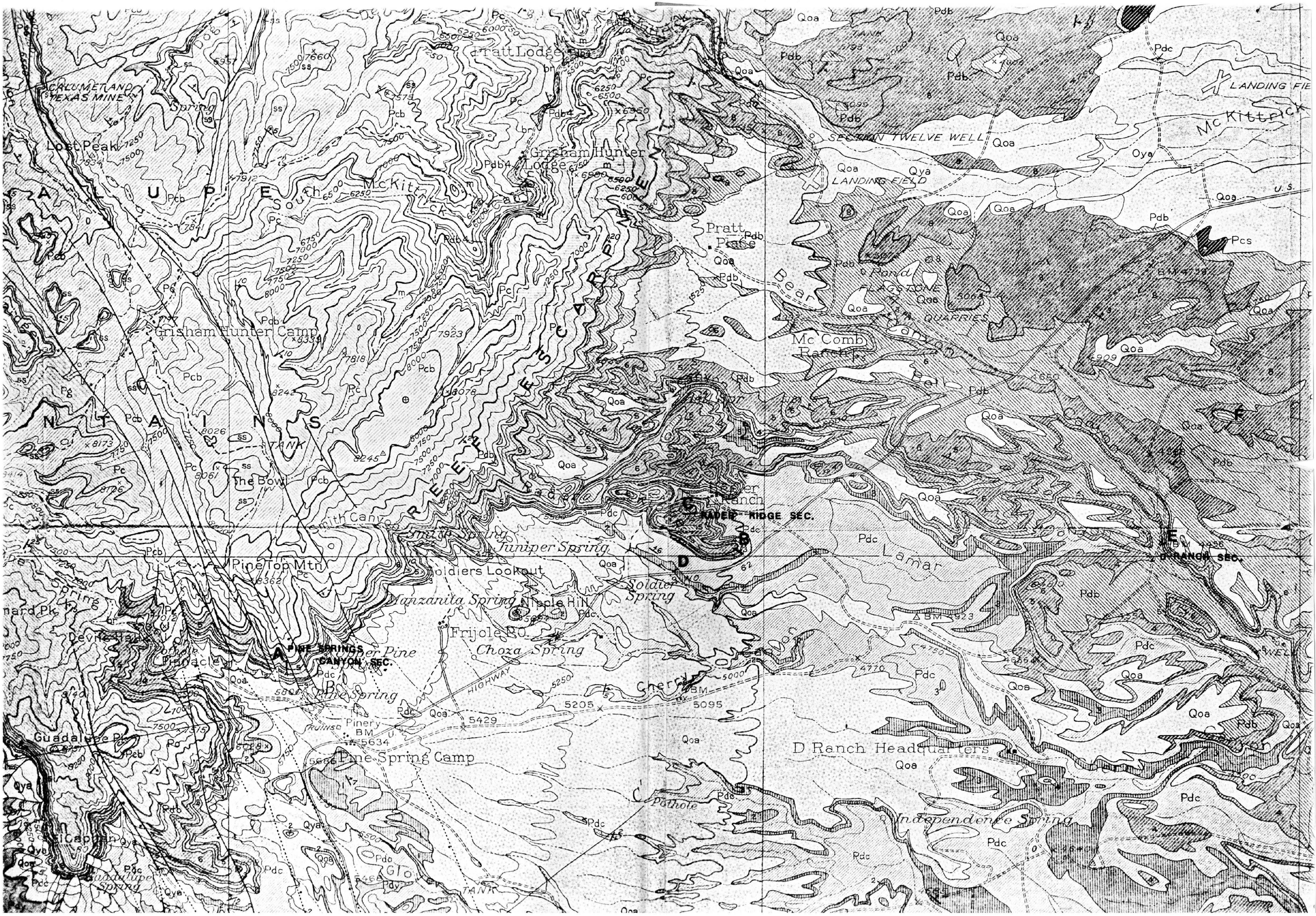
Sweet, Walter C., 1970. Uppermost Permian and Lower Triassic conodonts of the Salt Range and Trans-Indus Ranges, West Pakistan: in Kummel, B., and Teichert, C., Eds., Stratigraphic Boundary Problems: Permian and Triassic of West Pakistan: University Press, Kansas, Dept. Geology, Univ. of Kansas Spec. Publ. 4, pp. 207-275, pls. 1-5.

_______, and Bergstrom, Stig M., Eds., 1970-1971. Symposium on Conodont Biostratigraphy, Geological Society of America, Inc., Memoir 127, pp. 415-439, pls. 1-2, 446-465, pl. 1.

_______, in publication, Conodonts of the Ali Baski and Lower Elikah Formations (Upper Permian and Lower Triassic), Julfa Region, Iran, pp. 1-54, pls. A-C.

Tatge, Ursula, 1956. Conodonten aus dem Germanischen Muschelkalk: Palaont. Zeitschrift, Bd. 30, p. 108-127, 129-147, pl. 5-6.

Youngquist, W. L., Hawley, R. W., and Miller, A. K., 1951. Phosphoria conodonts from southeastern Idaho. Jour. Paleontology, v. 25, n. 3, pp. 356-364, pl. 54.



CALUMET AND TEXAS MINE
Lost Peak
Pratt Lodge
Grisham Hunter Lodge
South McKittrick
SECTION TWELVE WELL
LANDING FIELD
McKittrick
Pratt Place
Bear Canyon
FLAGSTONE QUARRIES
Mc Comb Ranch
Grisham Hunter Camp
The Bowl
REEF ESCARPMENT
GUADALUPE
MOUNTAINS
Smith Canyon
Smith Spring
Juniper Spring
RADER RIDGE SEC.
D-RANCH SEC.
Lamar
Pine Top Mtn.
Soldiers Lookout
Manzanita Spring
Nipple Hill
Soldier Spring
Frijole P.O.
Choza Spring
PINE SPRINGS CANYON SEC.
Pinnacle
Pine Spring
Pinery
Pine Spring Camp
Guadalupe Pk.
El Capitan
Guadalupe Spring
Cherry
HIGHWAY
Pothole
D Ranch Headquarters
Independence Spring